ALASKA OREGON WASHINGTON
PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
USDA FOREST SERVICE RESEARCH NOTE

PNW-294 March 1977

# MORPHOLOGY OF THE INTERNAL REPRODUCTIVE ORGANS IN RELATION TO THE SEX PHEROMONE GLANDS OF THE SPEAR-MARKED BLACK MOTH



by

Richard A. Werner, *Research Entomologist*

*ABSTRACT*

The morphology of the male and female internal reproductive organs of *Rheumaptera hastata* (L.) is described and illustrated. A new type of sex pheromone-producing gland was found in adult females. Unlike those of other Lepidoptera whose glands are modified intersegmental membranes, the paired glands of this geometrid moth are internal in structure and function. The opening of the common duct from the paired glands is in the posterior region of the vagina, and the sex pheromone is released by pulsation of the terminal abdominal segments.

KEYWORDS: *Rheumaptera hastata*, reproductive organs (insect), morphology, attractants.

## Introduction

The morphology of the internal reproductive system of the spear-marked black moth, *Rheumaptera hastata* (L.), has not been previously reported, though McGuffin (1973) described the external genitalia. The information presented in this paper resulted from a study on the role of sex pheromones in mating behavior of *R. hastata* (Werner 1977). Sex pheromone glands were found in the terminal abdominal segments of female moths and this prompted an investigation on the morphology of the reproductive organs in order to positively describe the location of the glands.

## Materials and Methods

Unmated adults of *R. hastata* were reared from field-collected pupae. Moths were anesthetized with carbon dioxide, wings and legs excised, and abdominal scales removed with adhesive tape (Fatzinger 1970). The insect was then dissected in Bouin's fluid and the exposed reproductive organs stained with fast green. Measurements were made on 10 moths of each sex using an ocular micrometer.

## Results and Discussion

The male reproductive system of *R. hastata* (fig. 1) is basically similar to that of other Lepidoptera in that the testes (T) are paired and enclosed in a single large spherical scrotum about 1.45 mm in diameter. The reddish-brown, thin-membranous scrotum is located dorsally between the third and fourth abdominal segments. The testes of newly emerged adults were filled with live sperm which suggests that male moths are sexually mature when they emerge from the pupa.

Paired vasa deferentia (VD), about 5-7 mm in length, arise from the ventral side of the testes and extend to the ductus ejaculatorius duplex (DED). Two seminal vesicles (SV) appear in each vas deferens about 1 mm distal from the testes. A second pair of seminal vesicles known as the accessory seminal vesicles (ASV) are located at the junction of the vasa deferentia and ductus ejaculatorius duplex. Live sperm were also found in the seminal vesicles which serve as a storage area for sperm.

The ductus ejaculatorius duplex is located dorsally, and the paired organs are fused posteriorly to form the single ductus ejaculatorius simplex (DES). Each duplex is about 3 mm long and 0.5 mm in diameter. At the anterior end, each duplex narrows to form an accessory gland (AG). The vas deferens enters each duplex near the anterior end. The accessory glands are 7.5 to 8.0 mm long and were found to contain a white substance. These glands, which secrete the seminal fluid, appear united but are merely connected by tracheal tissue. The ductus ejaculatorius simplex is about 22-25 mm long and in *R. hastata* consists of two distinct segments: the anterior primary segment (PS) and the posterior cuticular segment (CS). According to Callahan (1958), the simplex of *Heliothis zea*, is composed of two morphological areas as was found in *R. hastata*. But Outram (1970) describes seven morphological divisions in *Choristoneura fumiferana;* whereas, Norris (1932) found four divisions in *Ephestia kühniella* and Khalifa (1950) reported six divisions in *Galleria mellonella*. Fatzinger (1970) also reports two morphological divisions in *Dioryctria abietella*. The cuticular segment is differentiated into the ejaculatory bulb (EB) which functions in forming the spermatophore in most Lepidoptera including *R. hastata*. Spermatophore precursor substances were found in the primary segment of unmated males. The posterior end of the ductus ejaculatorius simplex terminates in the aedeagus (AE). McGuffin (1973) described the aedeagus as a stout structure containing three cornuti with the possibility that the cornuti are deciduous.

The female reproductive system (fig. 2) is similar to other ditrysian Lepidoptera in that the bursa copulatrix (BC) is connected to the common oviduct (OVC) by a seminal duct (DS). The ostium bursae (OB) opens externally midventral in the intersegmental cuticula of the seventh and eighth sternite and the ovipore (OP) and rectum (RE) on the ninth sternite.

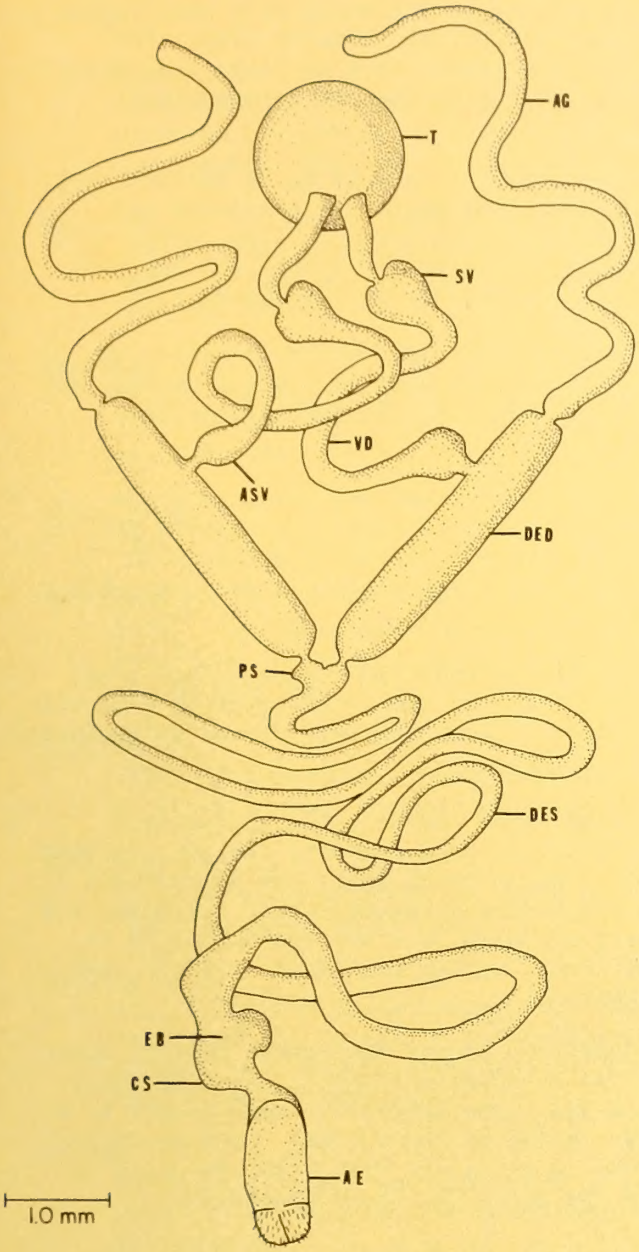



*Figure 1.--Reproductive organs of male R. hastata. AE, aedeagus; AG, accessory gland; EB, ejaculatory bulb; CS, cuticular segment of ductus ejaculatorius simplex; DED, ductus ejaculatorius duplex; DES, ductus ejaculatorius simplex; SV, seminal vesicle; T, testis; VD, vas deferens; ASV, accessory seminal vesicles; PS, primary segment.*

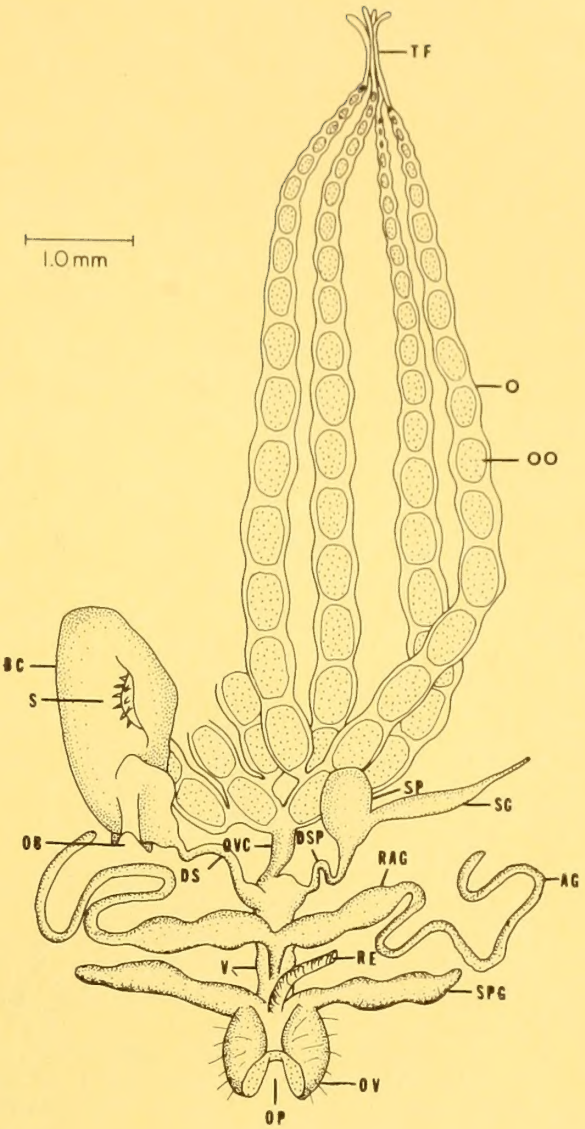



*Figure 2.--Reproductive organs of female R. hastata. AG, accessory gland; BC, bursa copulatrix; DS, seminal duct; DSP, spermatheca duct; O, ovariole; OB, ostium bursae; OO, oöcyte; OP, ovipore; OV, ovipositor; OVC, common oviduct; RAG, reservoir of accessory gland; RE, rectum; SG, spermathecal gland; S, signum; SP, spermatheca; SPG, sex pheromone gland; TF, terminal filament; V, vagina. Ovarioles of left ovary are not shown.*

The system contains paired ovaries, each ovary consisting of 4 polytrophic ovarioles (O) and each arising from a separate terminal filament (TF). The ovarioles of newly emerged, unmated females are longer (8-9 mm long) than the abdomen but are folded and extend from the seventh to the second abdominal segment.

Each ovariole of newly emerged females contains from 15 to 25 oöcytes (OO), with the mature oöcytes located at the proximal end where the ovarioles are connected by the short lateral oviducts to the common oviduct. The latter (2-3 mm long) is connected at the anterior end to the lateral oviducts and has two ducts leading into it before it terminates posteriorly in the vagina (V).

The first of the four ducts is the seminal duct (DS) which connects the bursa copulatrix to the common oviduct. The seminal duct is 1.0-1.5 mm long and opens into the common oviduct immediately posterior to the junction of the lateral oviducts.

The bursa copulatrix of *R. hastata* is a large brownish, muscular organ which was found to contain a spermatophore in mated females. In unmated females, the bursa copulatrix appears smaller and flattened. A heavily sclerotized signum (S) is located in the center of the bursa. The signun is somewhat oblong, 0.5 mm long, rigid with sharp spines.

The spermatophore is inserted through the sclerotized ostium bursae (OB), which is an external opening located midventrally in the intersegmental cuticula of the seventh and eighth abdominal sternites. The morphology of the spermatophore will not be described in this paper.

The spermathecal duct (DSP) (1.0-1.5 mm long) connects the spermatheca (SP) and spermathecal gland (SG) to the common oviduct opposite the seminal duct. Live sperm were found in the seminal duct, spermathecal duct, and spermatheca of mated females which indicates the latter functions to store sperm. Callahan and Cascio (1963) first described the movement of sperm from the spermatophore in the bursa copulatrix, through the seminal duct, across the common oviduct, and up the spermathecal duct to the spermatheca.

Posterior to the opening of the spermathecal duct, the common oviduct opens into the vagina. A pair of accessory gland reservoirs (RAG) (1.5-1.8 mm long) are situated posterior to the spermatheca and bursa copulatrix and connect by a common duct to the dorsum of the anterior region of the vagina. Each accessory gland reservoir constricts anteriorly into an accessory gland (AG) (4.0-5.0 mm long). A pinkish secretion was found in the accessory gland reservoirs.

*R. hastata* females have an additional pair of internal glands which open via a common duct into the dorsum of the posterior region of the vagina. These are the sex pheromone glands (SPG) and were found through bioassay to produce the female sex pheromone during courtship behavior. Previous reports indicate that all sex pheromone glands have external openings somewhere on the terminal region of the abdomen (Urbahn 1913, Götz 1951, Jefferson et al. 1968, Percy and Weatherston 1971). The sex pheromone glands of *R. hastata* open in the vagina, and the sex pheromone is released by a pulsating action of the terminal abdominal segments. Urbahn (1913) described similar internal glands in several species of Arctiidae and an external opening between the eighth and ninth abdominal tergite.

Posterior to the sex pheromone gland, the vagina opens into a telescopic ovipositor (OV), which has an ovipore for egg laying and for the dispersal of sex pheromone and accessory gland secretions. The ovipore is located on the fused ninth and tenth abdominal segment ventral to the anus.

## Literature Cited


Callahan, P. S.
1958. Serial morphology as a technique for determination of reproductive patterns in the corn earworm, *Heliothis zea* (Boddie). Ann. Entomol. Soc. Am. 51:413-428.

Callahan, P. S., and T. Cascio.
1963. Histology of the reproductive tracts and transmission of sperm in the corn earworm, *Heliothis zea* (Boddie). Ann. Entomol. Soc. Am. 56:535-556.

Fatzinger, C. W.
1970. Morphology of the reproductive organs *Dioryctria abietella* (Lepidoptera: Pyralidae (Phycitinae)). Ann. Entomol. Soc. Am. 63:1257-1261.

Götz, V. B.
1951. Die Sexualdufstoffe an Lepidoptera. Experientia 7:406-418.

Jefferson, R. N., H. H. Shorey, and R. E. Rubin.
1968. Sex pheromones of noctuid moths. 16. The morphology of the female sex pheromone glands of eight species. Ann. Entomol. Soc. Am. 61:861-865.

Khalifa, A.
1950. Spermatophore production in *Galleria mellonella* L. (Lepidoptera). R. Entomol. Soc. London (A) 25:32-42.

McGuffin, W. C.
1973. The *Rheumaptera* of North America (Lepidoptera: Geometridae). Can. Entomol. 105:383-398.

Norris, M. J.
1932. Contributions toward the study of insect fertility. 1. The structure and operation of the reproductive organs of the genera *Ephestia* and *Plodia* (Lepidoptera, Phycitidae). Proc. Zool. Soc. Lond. (Part 3):595-611.

Outram, I.
1970. Morphology and histology of the reproductive system of the male spruce budworm, *Choristoneura fumiferana*. Can. Entomol. 102:404-414.

Percy, J., and J. Weatherston.
1971. Studies of physiologically active arthropod secretions. 9. Morphology and histology of the sex pheromone producing glands of some female Lepidoptera. Can. Entomol. 103:1733-1739.

Urbahn, E.
1913. Abdominale duft Organe bei weiblichen Schmetterlingen. Jena Z. Naturwiss. 50:277-358.

Werner, R. A.
1977. Behavioral responses of the spear-marked black moth, *Rheumaptera hastata*, to a female-produced sex pheromone. Ann. Entomol. Soc. Am. 70:84-86.

The mission of the PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION is to provide the knowledge, technology, and alternatives for present and future protection, management, and use of forest, range, and related environments.

Within this overall mission, the Station conducts and stimulates research to facilitate and to accelerate progress toward the following goals:

1. Providing safe and efficient technology for inventory, protection, and use of resources.
2. Developing and evaluating alternative methods and levels of resource management.
3. Achieving optimum sustained resource productivity consistent with maintaining a high quality forest environment.

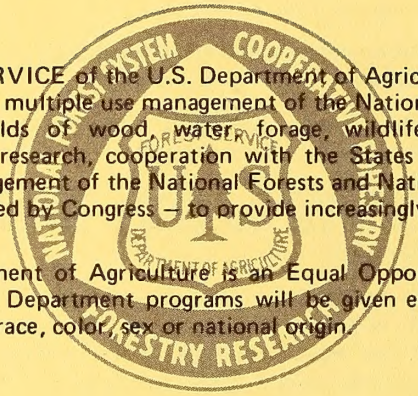
The area of research encompasses Oregon, Washington, Alaska, and, in some cases, California, Hawaii, the Western States, and the Nation. Results of the research are made available promptly. Project headquarters are at:

Fairbanks, Alaska
Juneau, Alaska
Bend, Oregon
Corvallis, Oregon
La Grande, Oregon
Portland, Oregon
Olympia, Washington
Seattle, Washington
Wenatchee, Washington

*Mailing address:* *Pacific Northwest Forest and Range Experiment Station*
*P.O. Box 3141*
*Portland, Oregon 97208*

GPO 998-269

The FOREST SERVICE of the U.S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives — as directed by Congress — to provide increasingly greater service to a growing Nation.



The U.S. Department of Agriculture is an Equal Opportunity Employer. Applicants for all Department programs will be given equal consideration without regard to race, color, sex or national origin.